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Published in:
The Global Network for the Economics of Learning, Innovation, and Competence Building Systems

Publication date:
2011

Monocausalism versus systems approach to development – The possibility of natural resource-based development

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Abstract:
Development economics have over the years produced several one-factor explanations by one-sidedly focusing on specific development factors or mechanisms as for example saving and investment, human capital, free markets, technology, institutions and production structure. In this paper we term such narrow monocausal explanations as 'fundamentalisms'. We identify and discuss several types of fundamentalism. We then argue that these diverse explanations of development in reality are interdependent and complement each other, and hence that the process of economic development must be understood as systemic.

Throughout the paper there is a focus on natural resource-based development. It has been argued that abundant natural resources are detrimental to economic development – an argument known as the resource curse, which is one type of 'production structure fundamentalism'. We argue that abundant natural resources can be a curse as well as a blessing. But if you can build an institutional framework for the utilization of specific natural resources, which supports development of new knowledge and competences that can be applied in a range of different activities, resource based development is possible. The latter is illustrated by examples from Norway, the US and especially Brazil. We conclude that it is not the various endowments per se that are 'fundamental' for development, but rather the by institutions sustained interdependency and interaction between the different types of development factors, and how these are managed or coordinated.

Keywords:
Root development factors; industrial structure; systems approach to development; structural change and innovation; natural resources

1 Introduction

Maybe as a result of exaggerated enshrining the KISS (keep it simple, stupid) principle development economics have over the years produced several one-factor explanations by one-sidedly focusing on specific development factors or mechanisms (Adelman 2001). At the same time there exists a deep mistrust among many scholars towards such mono-causal explanations, especially among economic historians: *"Economic analysis cherishes the illusion that one good reason should be enough, but the determinants of complex processes are invariably plural and interrelated. Monocausal explanations will not work"* (Landes 1998, p 517). In spite of such insights a strong focus on one single factor, which is believed to be the basic development factor or root cause of development to some degree continues to characterize development thinking and development policy. Recent examples of 'monocausalism' have centred around macroeconomic balance and free markets, knowledge, institutions, natural resources and the structure of economic activities. Accordingly we can identify elements of at least 'market fundamentalism', 'institutions fundamentalism', 'knowledge fundamentalism' and 'structure fundamentalism' in development thinking, where the notion of fundamentalism is taken to mean an exaggerated reliance on a rather narrow set of factors as the main cause of development. The tendency to seek mono-causal explanations, while often casting light on both the benefits and limitations of specific development factors, underestimates the complexity and context dependency of economic development and stands in the way for the formulation of usable development strategies and policies.

After shortly presenting some common forms of fundamentalisms we will take a closer look at structure fundamentalism. One type of structure fundamentalism is exemplified by the resource-curse argument. Here manufacturing activities are seen as the fundamental driving force in development which dismisses a proactive role for what we call natural resource-based industries. Consequently, an economic structure without natural resource-based industries is a 'good' structure. The point of this exercise is that we by critically scrutinising the foundations of this form of structure fundamentalism illustrate the weaknesses of monocausalism. We argue that the various monocausal explanations should be integrated in a framework capable of grasping a fuller picture of development, and that natural resource-based development can be a viable development strategy. On this basis we suggest an innovation system framework as a workable approach for grasping the complexities of economic development.

Additionally, the topic of natural resources and development is relevant and interesting in its own right. According to Ross (1999) twenty-seven of the thirty-six countries in the World Bank's most troubled category – severely indebted low-income countries – are primary commodity exporters. A better understanding of the role of natural resources in development could have far reaching consequences for such countries. Moreover, the issue of natural resources and development is currently an extremely interesting topic because the world is witnessing a 'new scramble for natural resources' (see e.g. Knaup and Mittelstaedt 2009). Developed countries have realised that knowledge is not sufficient to thrive in the knowledge economy – natural resources may be a necessary foundation for production, energy and consumption – especially the link between land, biomass and energy is growing in importance.

In next section we discuss the forms of *fundamentalism* mentioned above. In section three we consider the role of natural resources in structural change on the basis of structure fundamentalism. Here we use empirical examples in our argumentation – notably sugarcane and biofuel production in Brazil. In section four we present an alternative conceptual formulation of the role of economic structure in development. In section five we summarise the differences between these conceptual models by outlining a distinction between an endowment approach and a process approach to economics. The paper is concluded by a short discussion of how one can analytically approach the study of economic development and overcome fundamentalist tendencies.

2 Widespread types of fundamentalism

2.1 Market fundamentalism

During the 'Washington Consensus' in the 1980s and 1990s it was widely believed that policies for macroeconomic balance (which, oddly enough, did not include full employment) should be at the core of an effective strategy for development. Balancing state budgets, using restrictive monetary and fiscal policies to curb inflation and adjusting exchange rates to reduce current account deficits were referred to as 'getting policies right'. This was combined with institutional recommendations, which were supposed to strengthen the market mechanisms; financial liberation, trade liberalization, openness to foreign direct investment, deregulation, privatization and secure (private) property rights. This policy stance - stabilize, privatize, liberalize and let markets do their job - has been referred to as 'market fundamentalism' (Rodrik 2006).

The confidence in the Washington Consensus was eroded during the 1990s and there is now wide-spread agreement (also in the World Bank, see World Bank 2005) that it didn't work. The transition in Eastern Europe was accompanied by long and deep decline in spite of efforts to privatize and liberalize. Sub-Saharan countries failed to take off in spite of policies inspired by the Washington Consensus. Furthermore, there were frequent financial crisis in Latin America, East Asia, Russia and Turkey, there were disappointing growth rates in Latin America and there was a big crisis in Argentina in 2002, while developing countries that didn't follow the Washington Consensus (especially China and India) did very well (Rodrik 2006).

2.2 Institutions fundamentalism.

As a result of its failure the Washington Consensus became less narrow with less attention to macroeconomic balance and free markets and more attention to a somewhat broader set of institutions. Market fundamentalism developed into a kind of 'institutions fundamentalism'. The new slogan "get the institutions right" was substituted for the earlier ones "get the policies right" or "get the prices right" (Rodrik 2006). 'Good governance' became the new star among one-factor explanations of development. This now very common notion typically includes things like 'the rule of law', 'political accountability', 'transparency in policy-making' and 'quality of bureaucracy' (Kaufman and Kray, 2007).

A rather clear empirical correlation between good governance and the level of national income has been demonstrated over broad groups of countries and this is one reason that it has become an important target among development aid donors and in the World Bank. It should be noted, however, that 'good governance' is hard to define and measure in a precise way, which makes it difficult to apply in policy recommendations. It is, for example, not easy to define the rule of law unambiguously since there are different legal traditions in different countries. The meaning of political accountability, transparency and quality of bureaucracy also vary much from country to country because of different traditions and different complimentary institutions.

The mentioned type of institutions fundamentalism, which concentrates on good governance, can be placed within the transaction costs school. The policy approach is to support the kind of institutional changes, which are thought to reduce transaction costs. Such institutional fundamentalism fits better with static efficiency than with long run growth and development. It is close to what Coriat and Dosi (1998) calls weak (in contrast to strong) institutionalism and what Hodgson (1998) refers to as new (in contrast to old) institutionalism. There are, however, also examples of institutions fundamentalism, with a more dynamic outlook. For example, Douglass North (1990) focuses on how institutions shape incentives for change. 'Efficient property rights' form incentives, which induce people to make growth-inducing decisions. Under efficient property rights it pays-off for people to save and invest in production, education, research and so on. In contrast inefficient property rights lead to rent-seeking[1] behavior or even to directly harmful activities like piracy, violent crime and warfare.

The problem with institutions fundamentalism is that it tends to disregard other development factors, especially the interactions between technological and institutional change, and that it focuses on a too narrow set of institutions, i.e. primarily those related to transaction costs. Furthermore, it tends to underestimate the importance of context dependency for the effects of institutions. Every specific institutions works differently in different contexts, which makes it difficult to predict the economic outcome of simple institutional recommendations like 'reduce corruption' or 'strengthen property rights'.

2.3 Knowledge fundamentalism

Knowledge fundamentalism means that knowledge is taken as the root cause of development. It asserts that knowledge transfer from the North to the South and improved exploitation of knowledge constitutes a tremendous but underutilized opportunity in development. The roots of knowledge fundamentalism stick deep in economic theory. Marx (1859) made the development of the 'forces of production' (an expression for technology or knowledge) to the main source of social and economic change and Marshall (1890) stated that '…knowledge is the most powerful engine of production; it enables us to subdue nature and satisfy our wants'.

But knowledge fundamentalism in development theory and policy is more recent. It can be traced back to the exaggerated expectations about the development power of human capital that were common in the 1960s and 1970s, when the previous

[1] 'Rent-seeking is defined as the pursuit of uncompensated value from other economic agents, in contrast with profit-seeking, where entities seek to create value through mutually beneficial economic activity' (IMF 2005, p126)

concentration on investment in physical capital gave way to investment in human capital. It was also stimulated by the developmental success of some East Asian countries, which prioritized the accumulation of human capital before embarking on intense industrialization. Early contributions to new growth theory also implies that investments in knowledge and human capital are able to lift developing countries from a low-growth path to a high-growth path utilizing economies of scale (Adelman 2001).

More recently also the World Bank has emphasized the role of knowledge and knowledge diffusion in development. "*Knowledge is like light. Weightless and intangible, it can easily travel the world, enlightening the lives of people everywhere. … This World Development Report proposes that we look at the problems of development in a new way – from the perspective of knowledge*' (World Development Report 1998/99, p.1). The oversimplification that characterize one-factor explanations is accentuated in this quotation, which seem to follow the standard assumption in main stream economics that it is legitimate to reduce knowledge to information, which floats more or less freely between countries. However, as a whole this simplistic view doesn't characterize the World Bank report, which recognize both the complexity of knowledge and the costs of knowledge transfer.

It should also be acknowledged that the scholars who have emphasized knowledge as fundamental in economic development as a rule also have realized that it doesn't stand alone. Marx, for example, not only underlined the development of the 'forces of production' but also put it into a dialectical interaction with the 'relations of production', which primarily refers to the relations defining and enforcing the property rights to capital.

2.4 Structure Fundamentalism

The conviction that the most important factor for economic development for a country is its industrial structure may be called 'structure fundamentalism'. The argument that the economic structure (i.e. the specialization pattern) is the fundamental factor explaining economic development (structure fundamentalism) has two main pillars. (i) Most now-industrialized countries have gone through a similar process of structural change during their development process. Applying the tripartite classification of primary, secondary and tertiary sectors, the composition of GDP has moved away from primary production (agriculture) towards, first, secondary production (manufacture) and then tertiary production (services) (Kuznets, 1971). This pattern of structural change has the status of a stylized fact. It seems to indicates that changing the economic structure of a nation according the pattern mentioned is a necessary part of economic development.

(ii) The direction of structural change (away from primary production towards industry and services) indicates that some economic activities are better than others for generating wealth. This implies that changing one's economic structure towards such activities is a fundamental aspect of development. It might even be seen as the underlying, driving force of development. The argument that some economic activities are better than others comes in several forms. It is often argued that especially manufacturing industry is superior to primary production in terms of technological possibilities, income elasticity, linkages and learning and innovation.

Regarding recent structural changes it is a standard observation that services, as a basic characteristic of the knowledge-based economy, are superior to both primary and secondary production in terms of the same parameters (Cohen and Zysman, 1987).

Along similar lines Reinert (2007) presents a distinction between high and low-quality economic activities. Economic activities with high productivity growth, high potential for further technological improvement, facing increasing demand and characterised by imperfect competition and high barriers to entry are high-quality economic activities (in this category we find so different examples as golf balls and Apple computers). Low quality-economic activities are characterised by close-to perfect competition, low productivity growth, limited potential for further technological improvement, low income elasticity of demand, barriers to entry based on low wage rather than knowledge and little learning (examples are shoes and baseballs). Reinert (2007) especially emphasizes the historical importance of the manufacturing industry as propelling development via ‘increasing returns to scale’. At the same time he dismisses agricultural industry as a base for development primarily because it has historically been subject to diminishing returns to scale.

These propositions are in accordance with the recent resource-curse literature (see e.g. Sachs and Warner, 1995; Gylfason, 2001). The argument is that natural resources will prevent an economy from embarking on a prosperous path of structural change and development because they are subject to a ‘pathological disorder’ (Gunton 2003). Following this logic development policy should aim at changing the economic structure of countries towards a structure dominated by higher shares of manufacturing and services, and consequently away from natural resource-based industry[2]. Hence, ‘getting the economic structure right’ is the mantra of this approach to development.

Still, the argument does not fit well with the fact that some countries have *moved* from being natural resource-based economies to being considered advanced, knowledge-based economies, as e.g. most Scandinavian countries and the US (cf. next section). Moreover, according to Smith (2007), it is a misunderstanding that all natural resource-based economies are poor. On the contrary, some of the richest, and/or fastest growing, economies today are resource based. According to Smith (2007) these economies include Norway, Sweden, Finland, Canada, New Zealand, Australia and the Netherlands. This paradox indicates that natural resources are not unambiguously ‘bad’, and that structure fundamentalism may be misleading.

We will in the nest section take a closer look at the arguments underlying both structure fundamentalism and the resource curse. We will do so on grounds of logic and empirical examples of natural resource-based development.

3 Natural resources and Development

We will take the negative perception of natural resources that structure fundamentalism contains as point of departure for this section. The main proposition of the latter is that some economic activities (production of certain goods) are

[2] This discourse resembles the low versus high-tech debate (Smith, 2002).

qualitatively better than other activities with respect to generating economic development. This establishes a hierarchy of economic activities where services and especially manufacturing are the main drivers of economic development while primary production[3] is detrimental to development. We will approach the topic by looking at the resource-curse literature.

This literature argues that natural-resource abundance tends to be associated with meagre economic performance on the country level. Evidently a correlation can be found between the two parameters, but the suggestions for causality are many – we will focus on the two most dominant; the Dutch disease and the absence of linkages. We will discuss the core issues in these propositions for causality[4]. Below we will consider measurement of natural resources, the resource curse, and finally propose an alternative more dynamic view on natural resources.

3.1 Measurement of natural resources

A word of caution is required regarding the measurement of natural resources used in the resource curse literature. Firstly, natural resource-based industry or primary production is most often defined as fuels and non-fuel primary products which correspond to SITC categories 0, 1, 2, 3 and 68 (Sachs and Warner, 1997), see table 1 in appendix. Regarding measurement we find it relevant to comment on potential caveats: (i) definition of 'natural-resource abundance'; (ii) fallacy of aggregation; (iii) and the periods of time under consideration.

(i) 'natural-resource abundance' can inter alia be defined as natural resource-based industry in share of GDP, share of value-added, share of employment, share of export earnings or share export value-added at one point in time or over a period of time. These are the most often-used measurement indicators. Still, the indicators do not say anything about physical 'natural-resource abundance'. They reflect a given country's industrial structure and/or export composition – it illustrates the absence of the secondary and tertiary sectors, which is a 'negative' definition of natural resources. This set-up of data indicates the implicit understanding that the relative absence of manufacturing industries is a result of a rich nature. Hence, 'natural-resource abundance' in the following is to be understood as an industrial structure dominated by natural resource-based industry – not as a relatively large physical endowment of natural resources.

(ii) There is a general fallacy of aggregation in the resource-curse literature. It has been shown that processes of learning and capability building differs across firms, industries, place and time (Dosi 1988). It is highly likely that important differences exist between natural resource-based industries as for example mining, agriculture and fishery, and also within these categories there are differences in terms of crops, climate, topography, species and extraction – differences that require specific knowledge. This is also noted by Bridge (2008) who points out that it is remarkable that in the discussion of natural resources and development the nuances of specific

[3] Primary production will be used interchangeably with natural resource-based industry.
[4] We omitted two aspects of the resource-curse literature, (1) terms-of-trade debate and (2) instability in natural-resource markets. We think that we capture the essence of (1) even though we do not focus on it explicitly, and also we are not directly concerned with trade effects in this paper. We found that (2) clearly is related to issues of economic management and lack of economic diversification – points that we make without presenting this literature.

and contextual arguments have gone missing. This is inter alia seen by an almost exclusive focus on the *national level* which again ignores other types of foci such as sector differences, organisation of firms or capability building.

(iii) It is relevant to pay attention to the periods of time of measurement due to: (a) considerations about the pace of structural change and what can be expected in short vis-à-vis longer time spans. Statistical evidence for resource curse is often based on only a few decades of observation, but structural change may take longer, and will most likely not be visible in aggregate statistics (Wright and Czelusta 2002); (b) importance of 'external' events in a specific period might influence the observed phenomenon.

Furthermore, the structure fundamentalism, as understood here, rests upon the tripartite classification of the economy. However, there have always been ambiguities regarding the demarcation lines between the primary, secondary and tertiary sectors. For example, when reviewing problems of definition in Australia and New Zealand, Fischer (1939) explained that the basic idea was to draw a dividing line on the basis of 'substantial alteration' in form and character of primary materials. This was to be done through manufacturing operations where the end product would be classified as a secondary product. Still, as observed by Fisher (1952) 'it is not easy to determine the precise stage in the conversion of milk into butter or cheese when this work ceases to be primary and becomes secondary'. The fuzziness of demarcation lines was reflected by frequently changing official definitions in New Zealand (1890-1921), cf. textbox.

Year	**Definition of primary production**
General speak	Agricultural and pastoral production
1891	Agricultural, pastoral, mineral and other primary producers
1896	All persons mainly engaged in cultivation or acquisition of food products, and in obtaining other raw materials from natural sources – and including persons engaged in forestry, water conservation and supply, mines and quarries.
1901	Back to more narrow definition of 1891
1921 – broader again	Agricultural and pastoral farming, market gardening, poultry and bee farming, fruit growing, fishing and trapping, mining and quarrying, bush saw-milling, scrub cutting and gum-digging.

Table 1: Definition of primary production.

Fisher (1939) indicated that the changing definitions was partly a result of farmers/producers vanity – that they exercised political influence in order to be classified as belonging to primary production, because this meant being most important - being primary, while secondary had a negative connotation. This ambiguity casts doubt on the tripartite classification, and the usefulness of analyses based upon it.

3.2 The Dutch Disease

Though prominent in the resource curse literature, the Dutch Disease is really neither a disease nor Dutch. It is, according to Gylfason (2008), rather a recurring phenomenon that involves a reallocation of resources – for example from high-tech, skill-intensive service and manufacturing industries to low-tech, low-skill primary production – with lasting harmful effects on economic growth and diversification. The name remains in use because the Netherlands was the first patient to be diagnosed. The Dutch-disease model describes a situation where an economy suddenly receives windfall earnings from an unexpected discovery of natural resources – it is named after the Dutch discovery of natural gas in the North Sea in the 1960s. A gas export boom led to an appreciation of the Dutch Guilder, and subsequently total exports from the Netherlands decreased. The causality of the argument goes as this: (i) an export boom (of natural resources) leads to appreciation of the exchange rate which cet. par. tends to weaken the balance of payment; (ii) the export boom will draw capital and labour away from manufacturing sectors into the natural resource sector. This reallocation of resources will increase cost of labour and materials (because initially the economy was in equilibrium) and thus increase cost for all sectors, which will increase the general price level; (iii) because of the latter, and the currency appreciation, export of manufacture decreases and the price of non-tradeables rises; (iv) foreign income from natural-resource export will in turn be used to import now cheaper foreign manufactured goods (spending effect). As the natural resource-based industry grows it attracts key labour inputs from the rest of the economy, which benefits natural resource-based industry and non-tradeables sector.

Since the starting point is that the natural resource based industry can not lead growth and development (decreasing returns to scale), the process will inhibit long-term economic development in the country by negatively affecting the manufacturing sectors. In general the Dutch Disease has given precedence to a range of so-called crowding-out explanations for the resource curse. Scholars state that some factor *x* is positive for economic growth, and that 'natural-resource abundance' in some way crowds out *x*. Such arguments have been put forward regarding foreign direct investment, social capital, human capital, saving, investment, financial depth and inflation (Gylfason 2004). Several objections can be made to the argumentation but the most important is that even if we accept that natural resource-based industry is in some sense inferior to manufacture, then there are several degrees of freedom for the government to take counteracting measures. The Dutch Disease is basically describing bad policies. This part of the argument is strongly related to issues of institutions rather than to a problem with natural resource-based industry per se. In general it can be argued that authors within this part of the resource-curse literature are confusing demand effects and supply effects. Demand swings that can lead to windfall earnings and tempt governments into unsound policy are different from the processes of industrial dynamics that are behind technological learning and long term growth (Wright and Czelusta 2002).

Similarly, Reinert (2007) argues that historically manufacturing has shown increasing returns to scale while primary production has shown diminishing returns to scale. Reinert's argument is based on a classical proposition originating from Thomas Malthus (1798), who argued that an agricultural sector is subject to diminishing returns to scale, and thus can not drive economic development. The argument has two aspects. (1) Good land is scarce and when inferior lands are included in production, as production increases, the yield per unit of land will gradually diminish (intensive agro). (2) Since land is fixed in quantitative terms by nature, it will inevitably be subject to diminishing returns to scale (extensive agro), whereas in manufacturing the intensive use of capital (machines can produce machines – land can not produce land) and increasingly specialized division of labour, can generate productivity improvements without 'natural' constraints (ecological factors were not yet introduced in the argument) and hence generate increasing returns. Thus, in order to promote economic development resources should be allocated to manufacturing. It is worth noting that underlying this argument is an idea of natural resources as being finite, and thus exhaustible. This is the basis for arriving at the diminishing returns to scale conclusion.

An acceptance of Malthus' argument, and the vast number of examples of 'backward' and 'simple' natural resource-based economies in recent history, have played an important role in establishing a consensus in economics, which states that in natural resource-based activities there is very limited learning, innovation, technical progress and productivity growth, and therefore such activities can't lead development. The point is reflected in the method of argumentation used by Matsuyama (1992) on the role of agricultural productivity, where he at the outset assumes learning by doing in manufacturing and no learning in agriculture. One could argue that when operating with such assumptions, conclusions are given a priori.

A general objection to this perception that could be made is that the obvious omission in Malthus' argument is the role played by technological progress, which has continuously increased agricultural productivity. Ferranti, Perry et al. (2002) show that productivity growth in agriculture has outpaced that of manufacturing in both developed and less developed countries during the 20th century. More precisely, they find that in the period 1967 to 1992 total factor productivity growth was significantly higher in agriculture than in manufacture; especially in developed countries. On this basis the authors conclude that "*natural resource-based activities can have high productivity growth, technical spillovers, and forward and backward linkages as much as modern manufacturing…the view that manufacturing has something special must be called into question*" (p. 4-7). The latter point indicates that the proponents of the negative perception of natural resources tend to confuse historical coincidences with universal laws.

3.3 Linkages and Natural Resources

An important reason for emphasising the role of manufacturing in development is its linkage potential. The argument was put forward by Albert Hirschman (1958) in connection with his work on less developed countries. Linkages can be either horizontal[5] or vertical, and are basically channels of transaction and communication between firms and other actors. Vertical linkages can be either backward or forward[6]. Hirschman (1958) starts from the complementarity between economic activities and investment decisions. He argues that economic structure influences investment incentives. It is more 'interesting' for industry A to invest, if industry B also invests, which is called a linkage effect. Linkages are seen as the basis for inter-industrial dynamics, which in turn stimulate structural change and development by enabling virtuous circles of investment, production and development.

[5] Horizontal demand linkages are mainly income effects. If industry A invests in new technology that decreases price of its products, then consumers will have a relatively higher income, which will increase demand for other products. Horizontal/income linkages must per definition affect all industries evenly. These are thus not of our interest.

[6] Vertical linkages focus on inter-industrial demand and related incentives for investment decisions. With vertical linkages one industry can create growth in other industries via its demand for intermediate goods as inputs to production. Assume industry A is upstream to industry B. An investment decision in industry A (technological upgrading) will not necessarily lead to higher profits, unless industry B also makes investments or else the demand for industry A's output will not rise. Industry A is dependent on industry B in order to fulfil the potential of its investment.

According to Hirschman some industries are better than others for generating linkage effects. He places primary production at the bottom of the hierarchy in this respect (with subsistence agriculture and/or export-oriented agriculture in mind, it seems). He argued (1958: p. 109-110): "*the lack of interdependencies and linkages is of course one of the most typical characteristics of underdeveloped economies…agriculture in general and subsistence agriculture in particular, are of course characterized by the scarcity of linkages effects. By definition, all primary production should exclude any substantial degree of backward linkage*[7]*…the case for inferiority of agriculture to manufacturing has most frequently been argued on grounds of comparative productivity. While this case has been shown not to be entirely convincing, agriculture certainly stands convicted on the count of its lack of direct stimulus to setting up new activities through linkage effects: the superiority of manufacture in this respect is crushing. This may yet be the most important reason militating against any complete specialisation of underdeveloped countries in primary production*". The arguments that primary production is inferior to secondary production in terms of productivity and linkages are closely connected.[8] Hirschman here represents a long tradition in economics for understanding the primary sector as inferior to the secondary sector.

The argument is that *backward linkages* are thought to be few because natural resource-based industry does not demand inputs. The input needed is nature, and nature is just there to be taken. It is assumed that the natural resources are directly available in nature. Also, backward linkages to science and capital goods are thought to be weak, because natural resource-based industry is assumed to be straightforward to manage. In the primary sector there is not application of sophisticated knowledge and no innovation. However, as also pointed out by Hirschman above, this is only true for the simplest perception possible of agriculture, as for example picking an apple from a tree. Still, today apple production is extensively mechanised and has linkages to science. Relevant knowledge bases are inter alia agronomy, precision agriculture, vaccines, and biotechnology.

Forward linkages are thought to be few because end products go directly to the consumer or are used as input to other industries in the form of raw materials. Raw materials per definition do not need processing – they are grown right out of the earth's crust wherefrom they are easily collected. If they were processed they would not be primary products. But these are simplifying assumptions rather than facts. Still, as pointed out by Fischer (1952) it is not easy to determine the precise stage in the conversion of milk into butter or cheese when this work ceases to be primary and becomes secondary. The products produced by natural resource-based industries, as defined in this work, are most often processed even though it may not be to the same degree as secondary products. Besides, demand for natural resources has risen over

[7] Hirschman does acknowledge that "the introduction of modern methods does bring with considerable outside purchases of seeds, fertilizers and, and other current inputs, not to speak of machines and vehicles. We may say that the more primitive the agricultural and mining activities, the more truly primary they are" (Hirschman 1958: p. 109-110). This does not change his main point, though.

[8] There are, at least, two arguments for why linkages can be weak, few or absent in primary production. (a) One argument is that the frequently seen foreign ownership of natural resource-based industry in less developed countries hinders linkages. (b) Another argument is that there is something special about natural resource-based industry – that the primary sector industries tend to have fewer linkages to other parts of the economy than secondary-sector industries. We will focus on (b).

the past decades to volumes that were earlier unimaginable in the form of food, raw materials and energy due to growth in global GDP and population.

Despite the obvious objections listed above, the understanding of primary production as exposed by Hirschman (1958) (mainly based on subsistence agriculture or enclave industries) is currently part of the resource curse thesis as illustrated by inter alia Reinert (2007), Gylfason (2004) and Humphreys, Sachs and Stiglitz (2007). Combined these studies have contributed to transforming context-specific experiences into a general conceptual model for understanding natural resources which reciprocally supports the tripartite model of structural change.

3.4 The nature of natural resources - finiteness and exogeneity

As mentioned the idea of finiteness of natural resources is the foundation for arguing that natural resource-based industry is subject to diminishing returns to scale. We want to challenge this position by arguing that the knowledge stock in a given country determines to which extent it is capable of identifying and utilizing natural resources. For example oil and minerals have been in the earth's crest as long as Homo sapiens have inhabited the planet, but it was only very recently that we identified oil as a valuable source of energy. The latter indicates that energy sources or natural resources to some extent are social constructs.

Zimmermann (1972) points out that a resource is defined by its *function*. Coal is a resource in as much as it serves the function of generating energy for various operations. Without this function coal would still be coal, but it would not be a resource. These remarks open the floor for a conflict between the viewpoints of natural science and social science; "*if nature is thought of as the universe, it may be considered constant…Nature in that sense is the topic of natural science. The social scientist is concerned, not with the totality of the physical universe, but with the meaning of nature for man, with that ever-changing portion of nature that is known to man and affects his existence. That portion is both expanding and contracting. It expands in response to increase in knowledge and improvement of the arts. Nature reveals herself gradually to man, but no faster than he can learn*" (Zimmerman, 1972, 80)[9]. It is therefore straightforward to denote the natural scientist's view of nature as *nature*, and denote the social scientist's view as *natural resources*, see table 1. In the interface between nature and natural resources there are ongoing processes of resource creation, resource obsolescing and resource extension[10].

Natural science (nature)	**Social science (natural resources)**
Constants of natural science	'relatives' of social science
The world a bundle of hay – zero sum game	Non zero sum game
Natural resources *are*	Natural resources *become*
Abstract or physical perception of natural resources. Nature exists only because it exists,	Functional perception. A natural resource is a mean to an end, an end defined by man and

[9] We are aware that natural science and social science do not necessarily use such simple and stereotypic perceptions of nature, but we ignore this diversity here for the sake of illustrating a relevant point – namely that there are different perceptions (both within and across disciplines), and that they matter greatly.

[10] Still, the issue of finiteness must be considered in relation to the aspect of time. In the (very) long run availability of energy and matter to humans is finite, which ought to affect technical change in the direction of energy and material-saving production, and a higher use of renewable sources (Georgescu-Roegen, 1975). This is an important perspective, but for understanding processes of economic development, we must focus on shorter time horizons.

there is no function behind the existence of our planet and its characteristics.	society, which makes it functional.
Static perception of natural resources	Dynamic perception of natural resources
Land supply is given and fixed	Land: its function, yield and supply must be interpreted in relation to time, space and knowledge.
Nature = natural resources	Nature is converted to natural resources in a process of learning and knowledge accumulation

Table 2: Nature and natural resources.

Rubber from the Amazon had been known to westerners for centuries but it was not until Charles Goodyear discovered 'vulcanization' in 1839, that rubber became a resource (creation). It became a resource because his discovery made it possible to satisfy human wants with the use of rubber. Eventually rubber production from the Amazon region was overtaken by producers in South-East Asia (obsolescing), and both were later overtaken by production of synthetic rubber (extension), which was developed during World War 2 (Zimmermann, 1972). Obviously, these processes are characterized by learning and accumulation of knowledge. Rosenberg (1976) argues that successful processes of resource creation and extension have been the foundation of countries' capability to follow the shifts in dominant energy sources and materials that have characterized economic development the later centuries. 'Knowledge explosions' have historically undermined the tendency to diminishing returns to scale in natural resource-based industries.

The idea that natural resource-based production has few or no linkages – seeing them as exogenous to the economic system - contributes to a negative perception of natural resource-based industry for two reasons. (1) Linkages are about spread effects – how one impulse (demand and/or innovation) to the economic system can create further impulses. Without linkages, a sector can never generate structural change and development – it may finance it through exports, but it can not 'create' it. (2) Absence of linkages implies that learning and innovation is absent with respect to inputs (freely available) and outputs (no further processing). It implies that growth of natural resource-based industries will not lead to diversification; but instead to poverty. As argued above natural resources have, in principle, linkages of all kinds. Natural resources must be produced, and are not freely available in nature. It requires development of technology and knowledge to build ships to go fishing, to extract minerals, to exploit wind energy and to improve agricultural yields. This argument strongly relates to the points of extending and creating natural resources, and illustrates the necessity of understanding natural resources as dynamic.

In the following we will illustrate the above points by examples of natural resource-based development from Norway, Brazil and the US.

3.4.1 Natural resources in Norway

Norway has historically been specialized in natural resource-based industries. In the 19th century Norway responded to demands from the leading economy of the time, England, by increasing export of salted/dried fish and timber. The increasing transport of natural resources from Norway to England stimulated the development of shipping and shipbuilding industries as a backward linkage – by the 1880s Norway had against all likelihood the world's third largest shipping fleet. As a response to the growing natural resource-based industries several linkages to what we can call manufacturing appeared. Shipbuilding technology improved significantly, and production of intermediate products related to ship transport took off. Also, saw mills improved their equipment and implemented stream-driven saws in the 1870s. Norway actually started to export pulp and paper machinery in the 1890s. With respect to the fishing industry, whaling and canning took hold. In the 20th century new natural resource-based industries appeared. These were based on access to cheap energy. Due to development of capabilities in chemical and electronic engineering Norway had succeeded in exploiting its waterfalls for production of hydroelectricity, which attracted foreign investments in energy-intensive products as zinc, artificial fertilizers and aluminium (Cappelen and Mjøset 2009).

During the developments in the 19th century foreign capital played an important role, and foreigners had a strong presence in many areas. After independence from Sweden in 1905 Norway nationalized many parts of economy that were dominated by foreigners. Politicians implemented ‘concession laws’ that gave Norwegian authorities control over the relevant water resources. Still, the law changes allowed for joint ventures between national and foreign enterprises, which according to Cappelen and Mjøset (2009) was aimed at developing a Norwegian knowledge base for the relevant engineering supply industries. Subsequently, manufacturing of turbines and machinery for power production became significant backward linkages from hydropower. Also, after World War 2 production of components for automobile production developed as a forward linkage from the production of aluminium.

After World War 2 another natural resource-based industry was added to Norway’s portfolio – oil and gas. At the time when Norway discovered oil and gas it did not posses the capabilities necessary to develop an oil industry, which stimulated a process of foreign capital inflow and suggested a dominant role of multinational enterprises. In the spirit of the earlier concession laws Norway created a national oil company, Statoil, in 1972 which was put in control of oil extraction and distribution. The state in Norway had from the start a strategy on knowledge acquisition from foreign firms, and actually one of Statoil’s main tasks was to organise learning and technology transfers. Also, universities started up activities as research and education in areas relevant for the oil industry. According to Cappelen and Mjøset (2009) policy was targeted at developing linkages between the oil industry and suppliers. For example Statoil would exercise public procurement by placing orders with several old and new Norwegian firms, which resulted in that old shipyards were restructured into producers of oil-related technology. Mainly due to the rough Norwegian waters a new design for oil platforms was developed. Norway developed several product innovations that would later be internationally competitive. Also specialized engineering, ICT and other business services have benefitted from the development of the oil industry in Norway. It is moreover remarkable to note that other countries as England, Denmark and the Netherlands also discovered oil and gas in the same period as Norway. While such discoveries were associated with harmful economic effects (to manufacturing) in the Netherlands, it actually strengthened manufacturing activities in Norway (Fagerberg, Mowery et al. 2009).

The above reflects that the Norwegian state was actively building institutions and linkages to avoid a dependency and ‘enclave’ situation with the international division of labour in mind – and also that it is possible to do so. The institution building facilitated processes of capability building in several complementary areas related to oil production. It is an example of how co-evolution between natural resource-based industry and manufacturing contributes to economic development, and where natural resource-based industry is actually ‘leading’ the process.

3.4.2 Sugarcane in Brazil

The Brazilian experience in growing sugarcane and commercially producing sugar-based products as sugar, ethanol[11], bio-electricity[12], flex-fuel vehicles[13] and ‘green’ plastic (produced from ethanol), is an interesting story – one that brings another perspective on linkages in natural resource-based industry.

Brazil has produced sugarcane for more than four centuries, but only seriously started producing ethanol as a response to the international oil crises in the 1970s (Moreira and Goldemberg, 1999). A large-scale public investment program was launched (Proalcool) which considerably increased production and capacity. Since the launch of Proalcool there has been substantial productivity improvements in both sugarcane and ethanol production[14]. Sugarcane productivity has increased 2.3% p.a. between 1975 and 2004 while ethanol productivity has increased 1.17% p.a. on average in the same period (Matines-Filho et al., 2006). Furthermore, in Sao Paulo the mills have, since the start of Proalcool, achieved a 33% increase in tons of sugar per ha; 8% more sugar extracted from cane; 14% efficiency improvement in conversion of cane sugar into ethanol and 130% productivity increase in the fermentation process (UNICA, 2007). The Technological developments that lie behind these improvements can be divided into two periods. 1980-1990: introduction of new cane varieties; new grinding systems, fermentation with larger capacity; use of vinasse (by-product of sugar production) as fertilizer; biological control of sugarcane beetle; optimization of agricultural operations; autonomy in energy. 1990-2000: start of energy surplus sales; improved technical, agricultural and industrial management; new sugarcane harvesting and transportation systems; advanced industrial automation (UNICA, 2007). Since the year 2000 several other innovations have been generated where the more important are the flex fuel vehicle and increased capacity in co-generation of electricity.

The productivity improvements reflect learning and innovation activities in and around the natural resource-based industry. It is also clear that the cultivation of sugarcane has many backward and forward linkages to other parts of the Brazilian economy, cf. table 2 and table 3 in appendix. This implies that the activities going on within the sugarcane industry stimulate production, learning and innovation activities in related areas through linkage effects. The Brazilian example helps us to acknowledge that natural resources are clearly endogenous because there are important feedbacks and interactions via linkages, and there is significant dependence upon stocks of knowledge accumulated with respect to extension and creation of natural resources.

[11] Most commonly-used renewable biofuel.
[12] Bagasse (residue from the sugarcane) is burnt to heat water whose steam drives turbines. Recently sugar and ethanol mills are selling surplus electricity to the national grid and thereby increasing the role of sugarcane-based energy in the Brazilian energy matrix.
[13] Cars that can run on any mixture of gasoline and ethanol.
[14] Our focus here is geographically on the part of the industry placed in the state of São Paulo, which is the most industrialized, most developed and richest state in Brazil.

3.4.3 Minerals and oil in the US

According to Wright and Czelusta (1997; 2002; 2004) the US was 1913 the world leader in production of virtually every mineral. And this was not because of a proportional natural endowment of natural resources – instead it was a result of learning. Between 1900 and 1914 the US produced 10 times more copper than Chile even though Chile had, and has, a much larger geological endowment. The US mineral industries advanced in 1870s and 1880s due to huge capital investments, but the major breakthroughs took place in metallurgy and improved conversion processes as e.g. the Bessemer process which allowed for a far higher exploitation rate of the mineral. Moreover, according to Wright and Czelusta (2002) there is reason to believe that the US leadership in minerals was a significant factor in shaping, if not propelling, the US path to world leadership in manufacture. The US had significant 'materials-using bias' in technical change in 9 of 20 USA manufacturing industries between 1850 and 1919: "*Nearly all USA manufactured goods were closely linked to the natural-resource economy in 'one way or another': petroleum products, primary copper, meat packing and poultry, steel works and rolling mills, coal mining, vegetable oils, grain mill products, sawmill products, and so on. These observations by no means diminish the country's industrial achievement, but they confirm that American industrialisation was built upon natural resources*" (p. 5). Among key explanatory factors for the US's experience in minerals are; (a) liberal and softly enforced legal environment; (b) investments in infrastructure and public knowledge as geological surveys; (c) education and research in mining, minerals, geology and metallurgy in which the US was world leader at the time.

Oil is an extreme example of the mechanisms just described. The discovery of oil as a valuable natural resource was made in the US despite the country's relatively poor natural endowment of oil. The first oil well was established in 1859. Gradually the US built up the "American way of life" based on cheap oil and automobiles. By 1913 the US production of oil amounted to a bit more than 60% of world production despite the majority of known oil resources were located in the Middle East (Mousdale 2008). Often American geologists were employed as consultants by oil firms to help locate deposits of oil in the ground. The industry quickly saw the value of scientific knowledge which created linkages between academia and industry. Young geologists used the national US geological survey to apply the novel anti-clinical theory which successfully was used to locate oil deposits. The use of new theory resulted in better search methods. In general the oil industry invested in the accumulation of knowledge in geology to serve its activities which is reflected by the establishment of the Berkley and Stanford Universities that are children of the oil boom in California. Also, there emerged an important linkage to the chemical industry. Actually, with the development of petrochemicals in the 1920s, one may say that oil was instrumental in the transition of manufacturing in USA from traditional mass production to science-based technologies. Until the 1920s the base material in chemical industry had mostly been coal, but this changed radically in the following years. The shift from coal to oil as raw material brought the US to the world frontier in chemical industries. A drive for diversification created important forward linkages wherein new industries were created on the basis of new knowledge.

The above indicates that (i) it was not abundance of natural resources per se (in terms of deposits) that was the reason for American leadership, but learning and capability building; (ii) that the development of manufacturing industry was directly related to the development of natural resource-based industries.

3.5 Different Approaches

The different perspectives on natural resources described (exogeneity and finiteness) are consequences of different analytical foci. If one perceives natural resources as exogenous and finite, then an obvious analytical focus would be to search for the most efficient use possible of these scarce resources. On the other hand, if one perceives natural resources as endogenous and non-finite such that scarcity changes with knowledge accumulation, then the analytical focus would *also* include a search for understanding the processes of resource creation. If one wants to understand long-term development then it seems that to study allocation of current resources is less important than a dynamic perspective in which resources are both created and utilized. The difference between the approaches can be conceptualized as an 'endowment approach' (static) and a 'process approach' (dynamic) to economic development.

In the *endowment approach* one focuses on the given stocks of resources at ones disposal. These are subject to prices that are mainly set by conditions of scarcity. Considering current and estimated future consumption together with current and estimated decrease in global supply, it is possible to establish a scenario wherefrom one can deduct at what time we will run out of a specific resource, and how price movements will be until then. Based on this information, it is possible to calculate an 'optimal' extraction and sales rate of energy resources, which maximizes income from deposits (see e.g. Hotelling 1931). This view implies that given endowments and demand, the price of energy will rise continuously as will the share of GDP going to energy consumption. Based on such a view W.S. Jevons (1866) argued in his publication 'The Coal Question' that: "*I draw the conclusion that I think any one would draw, that we cannot long maintain our present rate of increase of consumption; that we can never advance to the higher amounts of consumption supposed. But this only means that the check to our progress must become perceptible considerably within a century from the present time; that the cost of fuel must rise, perhaps within a lifetime, to a rate threatening our commercial and manufacturing supremacy; and the conclusion is inevitable, that our present happy progressive condition is a thing of limited duration*". The situation would look different in a *process approach* where it is recognised that (a) deposits of energy often increases significant via improved search, (b) sources of energy has often changed (in modern economies), (c) it is important to search for substitute sources, (d) the ability to change energy sources is partly determined by prior innovation and capabilities, (e) energy is a source of competitiveness wherefore productivity in extraction and conversion is important, and (f) experiences and incomes from the process of energy resource utilisation may be used to build new competences in activities, which are not immediately related to these resources (Rosenberg 1976). A process view thus implies an active rather than passive approach to the economic exploitation of energy deposits even when there are vast reserves. The different perspectives and derived analytical consequences are summarized in table 2.

Parameter	Endowment approach	Process approach
Nature vs. natural resources	- Static, finite, zero-sum game - Physical perception like natural science - Land is fixed - Nature = natural resources	- Dynamic, alterable, non-finite, positive-sum - Functional perception in social science - Land-function can be extended via learning - Nature is converted to natural resources in processes of learning
Finiteness	Natural resources are finite and thus subject to 'decreasing returns to scale'.	Not necessarily finite. Important natural resources changes over time according to knowledge accumulation.
Linkages	Natural resources are freely available in nature - linkages	Not freely, they are produced. Creates linkages across the tripartite classification
Learning	Because of decreasing returns to scale and absence of linkages learning potential is limited.	Significant learning potential
Exogenous, endogenous?	Natural resources should be seen as an exogenous, independent stock of raw material	Natural resources are clearly endogenous because of their dependence upon stock of knowledge
Natural resources and development	Contradiction – natural resources are cursed, and will therefore block structural change.	Co-evolution – natural resources *can* serve as a base for diversification of the economy (structural change) via learning processes and linkage building
Policy consequences	Get out of natural resource-based industry, and into manufacture and services	Explore the role of natural resources in specific contexts. Focus on linkages and learning

Table 3: Endowment versus process approach to natural resources.

Obviously a process approach takes on a dynamic perception of natural resources, and is thus incompatible with both the resource curse and the tripartite understanding of structural change. It has been strongly indicated that manufacturing and services are not necessarily always 'better' for development than natural resource-based industry. One flaw of the resource-curse argument is that it rests on an endowment rather than a process approach to economics. The latter seems better suited for understanding processes of change regarding natural resources. In the next section we will present an alternative conceptual model of structural change that is capable of incorporating a process approach to natural resources and structural change.

4 A Process Approach to Structural Change

The patterns of structural change need to be carefully interpreted. The structural changes observed may be undeniable, but the causalities involved and the underlying processes are not convincingly explained in the tripartite conceptual model.

Kuznets noted that in 1948 over a third of the value of production of total manufacturing was accounted for by economic activities that did not exist in 1880, or had such a limited size that they in total only produced 3.2% of total manufacturing output (Kuznets, 1971, 319). Furthermore, it is clear that the automobile industry together with some related industries[15] are very important growth industries in this period. Even though the growth rate of this subsector of manufacturing was higher in

[15] As for example petrochemicals, oil, plastic and rubber in the US.

the period 1880-1914 than in 1914-1948, its increase in the share of the value of output grows more in the second period. Kuznets interprets this observation as a non-linear trend in the development of industries. An industry will make its growth potential count, not in the early turbulent phases of its growth, but only when it has a sufficiently large volume for its above average growth to make a substantial contribution to the aggregate income. Obviously one must pay attention to both volume- and price movements in order to understand an industry's contribution to national GDP. The latter implies that that economic growth does not emanate from a specific economic structure, but rather from shifts in it. Thus, which industries that can be identified as being 'good' for aggregate growth changes over time. Kuznets further argued that these changes in the economic structure were both outcomes and drivers of innovation. These findings indicate that it may be more interesting to focus on shifts in economic structure, than to claim that there exists a best structure for development.

In accordance with these considerations Lundvall (1985, 1992) proposes that viewing the economic structure in terms of vertical connections instead of horizontal ones can improve our understanding of the underlying mechanisms of structural change and the interactions between industries[16] - i.e. by taking a process approach. His starting point is that learning is predominantly interactive and that innovation must be understood as a *process*. In line with Kuznets, Lundvall argues that innovation is the main driver of structural change and development. In a vertical structure every part interacts with its input producers and/or users of output. Innovation often emerges in the interaction between different actors that are part of the vertical chain – a user-producer approach. This approach implies that innovations are strongly related to the prevailing economic structures and to the institutions, which affect patterns of interactions that generate changes in the structure. The focus is here on innovation in capital goods industry, not final consumer goods (even though the same approach can be applied there too).

The starting point for Lundvall's analysis is that users and producers are formally independent entities separated by a market, but durably related through linkages wherein transactions and communication, including more things than just prices and quantities, take place. Innovation is seen as a cumulative process and as emerging from a confrontation of user needs with technological opportunities. Users naturally know more about their own needs than producers, and producers know more about technological opportunities than users. Thus, in order to produce the best product for the user, the producer needs detailed information about needs in production. Also, the more information users have about technological opportunities, the better they are at formulating their needs. This situation entails interdependence between users and producers in a vertical – and the performance of the vertical as a whole depends on each component within it, as well as the institutional framework it is situated in, which makes performance systemic.

[16] A horizontal view refers inter alia to the categorization of primary, secondary and tertiary sectors. A vertical approach perceives the economic system as consisting of verticals (chains) of production that often crosses the tripartite categorization mentioned above. Economic systems in the 'industrial age' are most often characterized by vertical structures, whereas in pre-industrial societies primary, secondary and tertiary production were not separated, but all exercised by the same unit of production – a farm growing corn (primary), processing it into bread (secondary) and bringing it to the market for selling (tertiary). During successive 'industrial revolutions' the latter pattern of production was broken by an increasing division of labour and specialization.

The information needed in interactive innovation can not be communicated via price signals in a market – it also requires different kinds of qualitative, sometimes personal, interaction extended over time. It thus makes sense to distinguish between linkages, which only channel arms-length monetary transactions and durable linkages, which also channel qualitative information. Terms like the quantity of linkages and the quality of linkages may become useful.

The argument here is that primary production, manufacturing industry and services are interrelated and interdependent parts of an economic system (seen as consisting of verticals embedded in a larger structure), where changes in one part can stimulate changes in the other parts - they co-evolve. The latter was illustrated by the examples in the previous section. Hence, not only is it difficult to say that one part of the vertical is more important than another, but actually innovation often emerges from the interactions between these parts, which calls for a policy approach that focuses, not on 'good activities', but on the systemic performance of national verticals. This understanding merges with the insight of Kuznets since innovation leads to changes in production structure, and supports growth and development. Actually, Kuznets himself argued that the growth and development of several now-developed countries has been based primarily on the commercialisation and technological modernisation of agriculture rather than on industry per se. According to him it is a mistake to universally identify 'modern growth' with industrialisation and capitalism (Easterlin 2008).

Recently, Hidalgo et al (2007) have argued that the level of sophistication of the present product mix in an economy affects the speed of structural adjustment towards higher productivity activities and hence the speed of development. The sophistication of the product mix is characterized by how the products are related to each other. They may for example depend on similar infrastructures and institutions, they may use similar technologies and competences and they may deliver inputs to each other. In a more abstract version of a user-producer approach, networks of related products and activities may be seen as drivers of development due to the systemic nature of economic performance.

The historic process of structural change can be understood as an increasing division of labour (inter alia) driven by innovation (and vice versa), which results in verticals of production consisting of interdependent parts. Innovation, which drives shifts in economic structure and development, emanates from the prevailing economic structure, which consists of the verticals crossing the whole tripartite classification. Since it is generally not possible to identify one part in a changing structure as generally and permanently more important than others, they are all involved in generating development.

From the perspective of interactive learning it is relevant to reconsider Hirschman's observation that manufacturing has more linkage potential than primary production. Compared to other sectors manufacturing has historically been very well connected and thus a basic source of innovation. When interactive learning between firms is an important element in innovation processes the structure of linkages becomes important too. But it is the quality of interactions, formed by an enabling institutional framework, that matters the most, not the quantity of transactions. Consequently, what constitutes a 'developmental' or 'sophisticated' production structure changes over time. Structure fundamentalism contains, like the other fundamentalisms we have identified, valuable insights, but it is too static and must be complemented with attention to the quality of linkages, innovation and structural change in order to be of much help for understanding development.

5 Endowments and Processes

The alleged 'deeper causes' of development, which characterize the 'fundamentalisms' (markets, institutions, knowledge and economic structure) have, as was also the case of natural resources, both static and dynamic elements (or can be given both static and dynamic interpretations). The development factors can be understood in both an endowment approach and in a processes approach, cf. table.

Development factor	*Endowment approach*	*Process approach*
Markets	Transaction costs and macroeconomic balance determine development.	Stabilize, privatize and liberalize and let markets do their job to increase growth.
Institutions	The main characteristics of the institutional framework determine development, negatively and positively.	Institutional learning (i.e. adaptation and change of the institutional framework) determines development.
Knowledge	Stocks of knowledge (know how, know why, know what) drive development.	Accumulation and change of knowledge by learning (and forgetting) and innovation determines growth and development.
Economic structure	There is a close connection between economic structure and development. Development can be supported by getting the economic structure 'right', i.e. by increasing the share of 'good' (manufacturing and services) industries and activities and decreasing the share of 'bad' (primary) sectors.	Industries identified as good change over time. Development is driven by changes in economic structure resulting from learning and innovation rather than by a certain type of structure.

Table 4: Root factors of development: Endowments and processes.

The endowment view fits into a neoclassical theoretical framework in which endowments, and change of endowments, are exogenously given, trade is explained by comparative advantages and the pivotal point is an optimal equilibrium. The process view, in contrast, leans towards evolutionary and institutional economics with endogenous resource endowments, trade explained by dynamic comparative advantages and where focus is on a process of change with interaction and cumulative causation between the various factors of development.

Fundamentalism in development thinking may not always be harmful. As the much used notions 'knowledge based development' and 'resource based development' indicate (development is based on but not exclusively depending on knowledge or resources) there also exists milder and less objectionable forms of fundamentalism, which only claim that from a development policy point of view it may be a good idea to concentrate on a leading factor like investment in human capital or utilization of abundant and accessible natural resources. Furthermore, each of the fundamentalisms may be given a more dynamic interpretation or at least connected to more dynamic arguments.

The problem with fundamentalism in development thinking is not the ambition to find the most important development factor but rather that the approach is often more in accordance with an endowment view than a process view. Furthermore, there is a tendency to overlook the other development factors and, especially, to neglect the interdependencies between the different factors. For example, that technological and institutional change interacts (sometimes harmoniously, sometimes contradictorily) with each other in the development process is so overwhelmingly documented in historic research that any attempt to depict one of them as the deep cause of development at the expense of the other should be met with suspicion.

Generally, the development factors feed upon each other and set the stage for each other. Each of them is insufficient and appears 'fundamentalistic' when it stands alone, but when they are combined with each other in a process oriented model of development, which focuses on their interactions, the importance of each of them is, in fact, enhanced.

Inter alia the story of sugarcane in Brazil illustrates the latter point very well. Here the interactions between several factors such as natural resources, institutions, knowledge, market form, entrepreneurship and 'good' policy have over time generated beneficial shifts in the production structure surrounding the sugarcane production benefitting the Brazilian economy as a whole. It is not possible to explain this process in terms of monocausalism. The process should rather be understood as evolution of an economic system via interaction between different activities (crossing the tripartite classification) and development factors, which has increased the complexity and level of development of the Brazilian economy.

A counter pole to monocausalism is another form of fundamentalism, which should also be avoided – we can call it 'fundamental relativism'. It refers to an approach where all development factors are considered of equal importance, regardless of time and space[17]. We want to propose an approach which stands somewhere in between monocausalism and fundamental relativism. All factors of development are not always equally important. In specific cases it is normally possible to identify 'leading' development factors in specific processes. In for example the Brazilian case it is clear that the productivity growth of sugarcane cultivation (stemming from learning) is crucial for the performance of the industrial complex surrounding it. Therefore it is possible to say that this is an example of natural resource-based development, even though the development process would certainly not have taken place without the presence of other supporting development factors. Therefore an analysis must take all relevant factors as well as their relative weight and their interactions over time into account in the quest for understanding processes and causalities in economic development if a useful development policy is to be formulated.

6 Conclusion

Even though our discussion does not warrant anything near a full treatment of different approaches in development theory, our critique of 'fundamentalisms' cautiously points in a specific direction. As illustrated by our empirical examples, it is not the various endowments per se that are 'fundamental' for development, but rather

[17] An example is a growth theory where there is perfect and marginal substitutability among development factors – a constellation which in principle allows for development with any natural resource.

the by institutions sustained interdependency and interaction between the different types of development factors, and how these are managed or coordinated. Processes of cumulative causation between changes in development factors bring about contradictions and problems, which feed learning and innovation. Innovation is in the long run connected to structural change as new processes and products enter the economy. This implies that development is always and inevitably connected to structural change. It involves evolution of networks and other and patterns of interaction between different production activities, which feed structural change towards activities with higher productivity.

We suggest that in order to be well-equipped for grasping the nature of structural change and development, researchers must adhere to a process approach and reject the endowment approach and monocausalism. At the same time researchers should avoid 'fundamental relativism'[18]. Instead we propose an approach which falls somewhere between monocausalism and fundamental relativism. All factors of development are not always equally important. In specific cases it is normally possible to identify 'leading' development factors in specific processes. In our example from the Brazilian sugarcane industrial complex, cane cultivation is a leading factor – natural resources are a leading factor. Therefore it is justified to talk of natural resource-based development.

Still, there are no guarantees, and the crucial question in development policy therefore becomes whether you can make the development factors feed upon and support each other. It is obviously not enough to have access to abundant natural resources. That can be a curse as well as a blessing. But if you can build an institutional framework for the utilization of specific natural resources, which supports development of new knowledge and competences that can be applied in a range of different activities, resource based development may be possible. This possibility is also suggested by our Brazilian example where cane is the base for several competitive positions as e.g. sugar, biofuels, alcohol chemistry and 'green' plastics, sucrose chemistry and new materials, energy co-generation, and cellulosic fuel.

The above is in line with a later contribution from Hirschman (1981) where he acknowledged that the lack of linkages in natural resource-based industry as compared to manufacture was not a consequence of natural resource-based industry per se, but rather because the actors involved in these activities often were not capable of establishing new activities related to e.g. agriculture, and thus creating linkages, that were significantly distant from the ongoing activities in terms of knowledge bases and technology – what he calls technological alienation. The only reasonable solution is again to be found in an institutional arrangement that aims at overcoming such knowledge barriers.

The importance of institutions and structures as well as their changes in this understanding of development points in the direction of a broad system of innovation[19] approach to development theory and policy. The main reason for this is that a systemic approach necessarily focuses not only on factor endowments but

[18] With which we mean an approach where all development factors are considered of equal importance, regardless of time and space

[19] Defined in the 'classical' way as 'all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring' (Lundvall 1992)

rather on how the people controlling the endowments interact with each other and with other sectors of the economy. One of the fundamental insights from the innovation system literature is that economic performance is systemic. The latter implies that the whole is more than the sum of its parts, and that the interrelationships and interactions between elements are as important for processes and outcomes as are the elements themselves (Lundvall 2007). The innovation system approach thus embraces a *process view* on development, but it also acknowledges that such processes are not automatic and need to be coordinated. It provides an analytical framework for understanding evolution of complex economic systems and hence learning how to identify, diagnose and proscribe medicine for economic development. The ability to catch the interdependencies, interactions and the respective endowments all together in the analysis is the crucial point here – a point, which is not compatible with an endowment approach to economics or monocausal explanations.

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8 Appendix

Sachs and Warner (1997) define primary products or natural resource industries as 'fuels' and 'non-fuel primary products' from the World Data 1995 (World Bank). Non-fuel primary products corresponds to SITC categories 0, 1, 2, 4 and 68, and fuels corresponds to SITC category 3:

- 0 - Food and live animals
  - 00 - Live animals other than animals of division 03
  - 01 - Meat and meat preparations
  - 02 - Dairy products and birds' eggs
  - 03 - Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof
  - 04 - Cereals and cereal preparations
  - 05 - Vegetables and fruit
  - 06 - Sugars, sugar preparations and honey
  - 07 - Coffee, tea, cocoa, spices, and manufactures thereof
  - 08 - Feeding stuff for animals (not including unmilled cereals)
  - 09 - Miscellaneous edible products and preparations
- 1 - Beverages and tobacco
  - 11 - Beverages
  - 12 - Tobacco and tobacco manufactures
- 2 - Crude materials, inedible, except fuels
  - 21 - Hides, skins and furskins, raw
  - 22 - Oil-seeds and oleaginous fruits
  - 23 - Crude rubber (including synthetic and reclaimed)
  - 24 - Cork and wood
  - 25 - Pulp and waste paper
  - 26 - Textile fibres (other than wool tops and other combed wool) and their wastes (not manufactured into yarn or fabric)
  - 27 - Crude fertilizers, other than those of division 56, and crude minerals (excluding coal, petroleum and precious stones)
  - 28 - Metalliferous ores and metal scrap
  - 29 - Crude animal and vegetable materials, n.e.s.
- 3 - Mineral fuels, lubricants and related materials
  - 32 - Coal, coke and briquettes
  - 33 - Petroleum, petroleum products and related materials
  - 34 - Gas, natural and manufactured
  - 35 - Electric current
- 4 - Animal and vegetable oils, fats and waxes
  - 41 - Animal oils and fats
  - 42 - Fixed vegetable fats and oils, crude, refined or fractionated
  - 43 - Animal or vegetable fats and oils, processed; waxes of animal or vegetable origin; inedible mixtures or preparations of animal or vegetable fats or oils, n.e.s.
- 6 - Manufactured goods classified chiefly by material
  - 68 – Non-ferrous metals

Table 6: Natural-resource based industries.

Backward Linkages
1. R&D on crop varieties

2. Machinery & Equipment
- Mechanization of sowing, growing, harvest.
- Mills and equipment
- Transport
- Process automation

3. Special Services
- Highly developed agronomy competence
- Specialized technology consultancy

4. Research in plant genetics, chemistry, transport systems, agronomy, tropical agriculture, new materials, biotechnology, and engine technology.

5. Distribution Infrastructure

6. Marketing, economics and Logistics related to both domestic and, especially, international markets.

7. Regulation
- Meteorology and related disciplines of chemistry, physics.
- Sustainability

Natural resource-based industry:

Sugarcane cultivation

Forward Linkages

1. Sugar
- Several different types

2. Ethanol
- Hydrous and anhydrous

3. Plastic
- Ethanol-based plastics and starch-based plastics

4. Other co-products
- Cattle fodder, organic fertilizers.

5. Bio-diesel
- Ethanol can be further processed into diesel. Technology not yet commercially applied at larger scale.

6. Bio-electricity

7. Distribution Infrastructure

Table 7: Linkages in sugarcane ethanol industrial complex in Brazil (Dahl Andersen, 2009).

Activity	Technique	Knowledge base
Agriculture – developing, planting, growing, harvesting and transporting sugarcane	Analyzing soil qualities and local climatic conditions. Use of satellite monitor. Match soil information with a suitable genetic variety. Modern machinery.	Agronomy (plant genetics, plant physiology, meteorology, and soil science); Precision agriculture (requires the use of new technologies, such as global positioning (GPS), sensors, satellites or aerial images, and information management tools to assess and understand variations); Biotechnology; Genetics
Industrial processing – producing sugar, ethanol and co-products	Mill construction. Cleaning, sorting and crushing sugarcane. Processing. Automation systems.	Electro engineering; Mechanical engineering; Physics; Chemistry; Micro electronics; Micro biology; Bio-chemistry; Thermo chemistry; Hydraulics; Automation
Further processing of co-products - plastics	Producing plastic	Chemistry, Petro-chemistry, Bio-chemistry, Plant genetics, Bio-materials
Distribution and Transport	Quality control Storing Infrastructure	Meteorology (atmospheric chemistry); Logistics; Informatics; Material technology; Systems engineering
Marketing phase	International market penetration. Sustainability responsibility and green products – certifications. IT control systems and international standards. Patenting competences	Logistics; Informatics; Economics

Table 8: Knowledge bases in sugarcane ethanol industrial complex in Brazil (Dahl Andersen, 2009).